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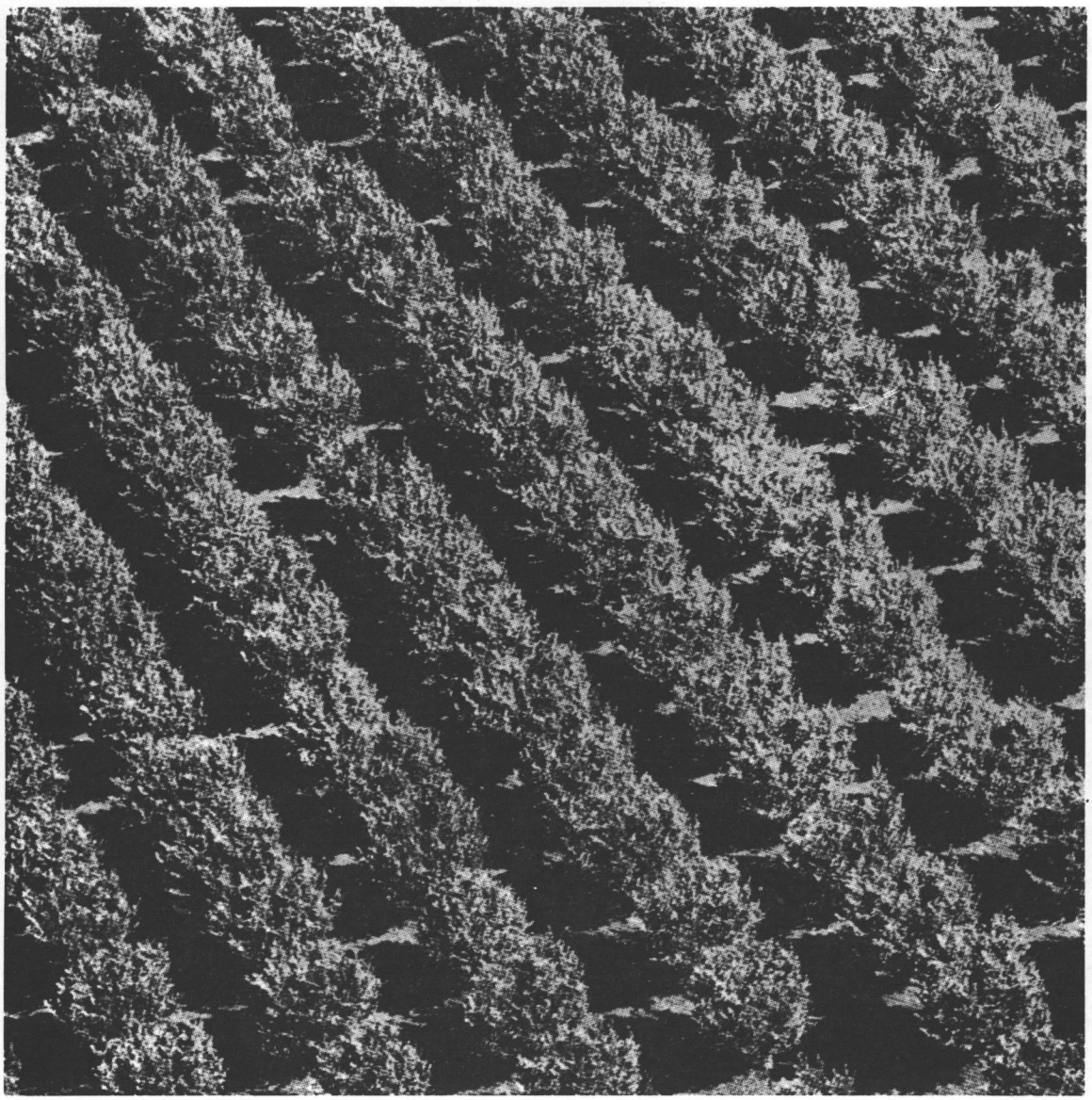
Growing Hazelnuts in Oregon



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Hazelnuts have been cultivated for many centuries. Pliny, in 60 A.D., narrated, "Filberts and hazels... are a kind of nut and were called heretofore Abellinae, of their native place... they come out of Pontus into Natolia and Greece and therefore they may be called pontic nuts." The hazelnut is a widely distributed species in Europe and into Asia.

Some authorities believe that the name *filbert* was originally *full beard,* referring to the fact that in some varieties the husk entirely covers the nut. Others believe the name has been derived from St. Philibert because August 22, the date dedicated to him, corresponds to the ripening date of the earliest hazelnuts in England. Although growers in Oregon usually call them *filberts,* most customers know them as *hazelnuts.*

While there is one species of hazelnut *(Corylus cornuta)* native to Oregon, the cultivated varieties of hazelnuts *(Corylus avellana)* were introduced to the United States from Europe by Felix Gillet, a nursery manager in Nevada City, California.

Between 1885 and 1905, he introduced Barcelona, DuChilly, Daviana, Hall's Giant, Montebello, Nottingham, and others. Some of these varieties are still grown in the Pacific Northwest today.

The natural growth of the hazelnut (filbert) is a bush or a multitrunked, shrubby tree. In Turkey and southern Europe, it has been grown in this manner for centuries. In Oregon, however, hazelnuts usually are grown as single-trunk trees that may attain a height of 30 feet under proper management and soil conditions.

While the hazelnut tree itself is quite hardy, it produces satisfactory crops only under moderate climatic conditions. The catkins freeze at 15°F. The female flowers, which bloom during January and February, will freeze at 10°F.

Further, the tree cannot tolerate excessive dry summer heat, so the production of hazelnuts is limited to the Willamette Valley in Oregon and to corresponding areas in Washington and British Columbia.

The tree may produce a few nuts when 2 or 3 years old, but it is not considered to be in commercial production until it is 6 years old. Mature orchards produce from less than 1,000 pounds of dry nuts per acre to better than a ton or more. A well-managed orchard will produce about 1,500 pounds of dry nuts per acre as an average. It should remain productive up to 40 years or more.

Economic importance

Crop value

The contribution hazelnuts make to Oregon's economy is considerable. Between 1979 and 1983, the crop varied from 7,500 to 18,400 tons, and cash farm receipts ranged from $3 to $17.4 million. The value added by processing is about 43% of the cash receipts. Therefore, the hazelnut industry contributes between $12.3 and $38.3 million annually to Oregon's economy.

Geographic distribution

Hazelnut orchards cover the Willamette Valley of Oregon from Eugene to Portland and from the foothills of the Coast Range to the foothills of the Cascade Mountains. Hazelnut trees grow best on deep river-bottom soils, but they also thrive on a wide variety of other soils.

The dominant feature controlling the distribution of commercial hazelnut production is the moderate climate of the coastal valleys of the Northwest as provided and influenced by the Pacific Ocean.

In 1980, there were nearly 22,000 acres of hazelnuts in Oregon. There is sufficient nursery stock produced to plant about 1,000 acres annually. Suitable hazelnut land is available, and the industry has been increasing by roughly 800 acres per year.

Virtually all of the commercial production of hazelnuts in the United States comes from the Pacific Northwest. About 97% of the U.S. production comes from the Willamette Valley in western Oregon. Washington produces the remaining 3%.

The Northwest's production is 4 to 6% of world hazelnut production and 2 to 3% of U.S. domestic production of all tree nuts (including hazelnuts, walnuts, almonds, and pecans). Hazelnut prices are, therefore, influenced by the world production and supply of hazelnuts—as well as the supply of all other nuts.

Marketing aids

The Filbert/Hazelnut Marketing Board, created in 1949, administers a Federal Marketing Order. The board is composed of five growers, three processors, and one nonindustry member. The marketing order provides for the marketing of inshell nuts according to market demands. Production beyond the demands of the inshell market must be shelled.

The Filbert Bargaining Association, formed in 1972, bargains for grower price and delivery conditions with all packers of record. In 1980, the association represented about 60% of the total tonnage in Oregon.

The Oregon Filbert Commission was established in 1951 for sales promotion and production research. Commission members are growers. Commission activities are financed by grower assessments.

In recent years, large nut-marketing organizations from California have begun to sell Oregon hazelnuts.

Production costs

Production costs usually are classified into four major categories: cultural operations, harvesting, drying and handling, and fixed charges. Representative costs based on 80 acres of mature hazelnut trees were estimated at $1,137 per acre in 1982 by Oregon State University farm management specialists, county Extension agents, and selected growers.

At the time of publication, no more recent cost analyses were available. Around 30% of these costs were allocated to cultural operations; 53% were fixed charges; and 15% represented harvest, drying, and handling.

Total cash costs amounted to $344.43 per acre, and the total noncash costs were $793.27. Assuming a 1,400-pound yield per acre, the cost per pound would be 78.8¢; with an average yield of 1,800 pounds per acre, the cost per pound would be around 63.2¢; at a yield of 2,200 pounds, costs are 53.5¢; and at 2,800 pounds, 46.7¢.

Thus, it is important to follow recommended practices for increasing yields and to include all costs in determining the profitability of growing hazelnuts.

Locating the orchard

A major factor to consider in locating a hazelnut orchard in western Oregon seems to be soil; however, do not overlook air drainage. While low temperatures during the blossoming season have not been known to limit yields, late April frosts in low-lying areas frequently reduce cluster buds and succulent green shoots.

No single direction of slope is better than any other, except as it affects soil depth and moisture retention. Hazelnuts do not tolerate wet soils during their active growing season, but since they are more shallow-rooted than most fruit trees, they will grow well in locations that may be marginal for crops like cherries or walnuts.

Very few plantings have been made on sites above 1,500 feet elevation; therefore, it is difficult to evaluate their worth as commercial sites. Plant orchards on sites that you can commit to long term tree growth. Avoid sites that are likely to be claimed for subdivisions, freeways, or industrial property within the next decade.

Suitable soils

An abundance of suitable land still exists in western Oregon for hazelnut culture; consequently, hazelnut orchards should not be located where the soil is poorly drained, shallow, too heavy, or too light.

Trees may grow well on shallow soil for the first 8 to 10 years—but then become poor producers because they cannot develop deep root systems. A hazelnut orchard that is relatively unproductive because of unsuitable soil can be a liability.

Although most of a hazelnuts tree's roots are found in the first 2 feet of soil, soils that are suitable for hazelnuts will allow the trees to develop active root systems to depths of 6 to 10 feet. Root penetration can be stopped by rock, hardpans, high water tables, or a lack of aeration in the soil.

Hazelnut trees draw moisture from the upper soil layers more rapidly than at lower depths. The top 2 feet of soil may be dry by the end of June, while the third and fourth feet may take as long as August to dry.

Irrigation might overcome the low moisture problem presented by a soil that is too sandy or shallow, but there is considerable expense involved. Shallow soils are often poorly drained, so that irrigation would not necessarily improve their suitability for hazelnuts.

Likewise, irrigation is no remedy for soils that are too heavy. The greatest benefit of irrigation is in establishing an orchard to obtain large trees more rapidly.

Tile drainage of wet land has been attempted with varying degrees of success. On land in need of drainage, the subsoil layer that supports the water is usually so close to the surface that only a very limited depth of suitable soil remains above it.

If the subsoil is so compact and dense that water will not pass through, tree roots will not penetrate it to provide normal growth. Tiling such soils could increase the area available for root activity earlier in the year, but it would not provide the best growing conditions.

Where a small area of wet land intrudes into larger well-drained tracts intended for hazelnuts, drainage is justified because it allows cultivation throughout the area.

Determining soil suitability

The soil types of western Oregon have been classified and mapped. You can find soil maps in your county Extension and Soil Conservation Service offices. These maps give the soil series, texture, and (sometimes) the average depth for most potential orchard sites.

Referring to soil maps is your first step in determining the suitability of a site for hazelnuts. However, even though the map gives useful information on the proposed site, you'll probably have to investigate further.

To determine soil depth, dig several holes and examine the soil. A post hole digger, soil auger, or shovel will do the job. Examine the soil to a depth of 4 to 6 feet in enough spots in the field to discover any variations in soil depth. Poor drainage is indicated by a grayish, yellowish, or reddish mottling of the soil.

Dig holes in March or April and check to see if they fill with water overnight. Unless it has rained, water in the holes indicates the presence of a high water table. Hazelnut trees can withstand a fairly high water table in March and April, if it drops as the trees start to grow in May and if the soil below 4 feet drains freely.

The small feeder roots affected by the high water table will die, but when drainage occurs, new roots will grow and use the remaining moisture.

Some soils may require special fertility adjustments before planting. Base any adjustments on an OSU soil test interpretation by your Extension agent.

Hazelnut varieties

Table 1 outlines the characteristics of the major hazelnut varieties.

Barcelona (figure 1) is the principal variety grown in Oregon. Its popularity is based on the inshell market, which favors its round shape and superior flavor. The kernels of Barcelona have a coarse, brown outer coating, or pellicle, which is very difficult to remove completely, even after roasting. However, some processors have found ways to do it.

The Barcelona tree tends toward an alternate-year bearing habit. One serious weakness of the Barcelona is that it produces more blanks than many other varieties. A second serious weakness is its susceptibility to brownstain.

The second most common cultivar is Daviana (figure 1), which is used as a pollinizer for Barcelona. Daviana has a number of faults. It is susceptible to big bud mite *(Phytocoptelia avellanae),* which forms galls in both flower and vegetative buds. The shells are thin, which makes it easy for birds and rodents to selectively remove nuts. These two factors contribute to low yields.

The Daviana nut is long and does not look good mixed with the round Barcelona. When nursery trees are available, use Butler instead of Daviana as a pollinizer for Barcelona.

A breeding program is currently under way to develop varieties that have heavy annual production, fewer

blanks, and more desirable kernel characteristics.

The varieties Butler and Ennis (figure 1) were discovered by growers in their orchards. Their nut and kernel characteristics are acceptable to processors. Selections of Butler and Ennis are being increased by both layerage and graftage.

Ennis is not a pollinizer for Barcelona. It is a large nut with inshell quality that is slightly better than Barcelona. Ennis is more productive than Barcelona.

Butler was introduced as a replacement for Daviana. It will pollinize Barcelona and the early flowers of Ennis. Butler is more productive than Daviana.

Table 1.—Characteristics of hazelnut varieties

Size	Average % kernel	Shape	Size	Value as Barcelona pollinizer	Productivity	Smoothness of kernel
Barcelona	42	Round	Med-large	None	Moderate	Smooth
Butler	48	Oval	Med-large	Excellent	Moderate	Smooth
Daviana	52	Oval	Medium	Excellent	Very light	Smooth
DuChilly[a]	44	Long[b]	Large	Good	Heavy (alternately)[c]	Shriveled on outside
Ennis	47	Round	Large	None	Heavy	Some roughness
Hall's Giant	38	Round	Medium	Good	Low	Some roughness
Montebello	42	Round	Med-small	None	Moderately heavy	Smooth

[a]Falls in husk, not free of it.
[b]Characteristic crease on side of shell.
[c]*Alternately* refers to crop production every other year.

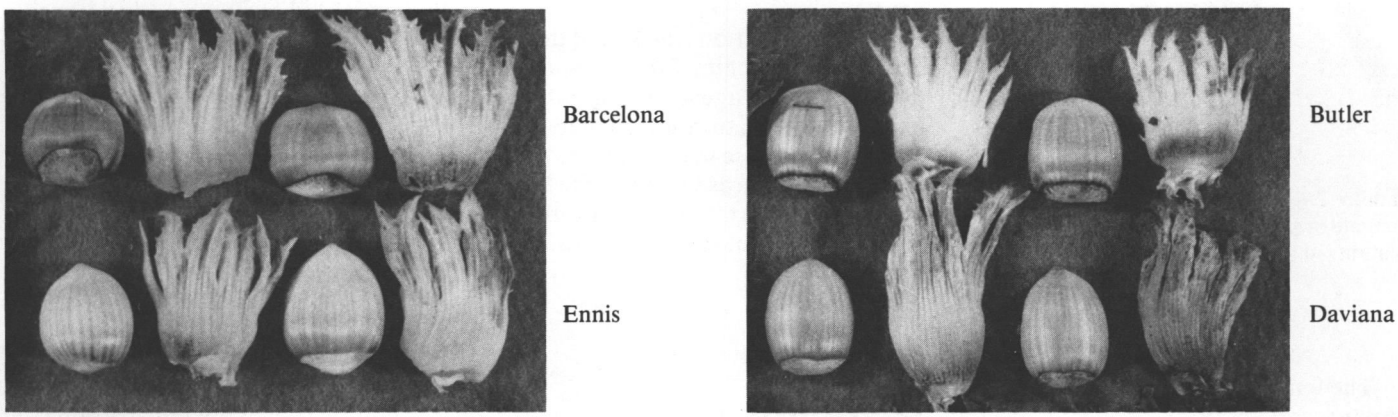

Figure 1.—Four prominent Oregon hazelnut varieties.

Nut development

To help you understand this section better, here's a glossary of the most commonly used botanical terms (figure 2 illustrates some of them):

Parts of florets (female)

Stigma. The uppermost part of the female flower at the end of the style, which receives the pollen. The stigma is red.

Style. Middle portion of female flower, between the stigma and the ovary.

Ovary. Lower part of the female flower. It consists of a wall of tissue (eventually the nut shell) and two ovules.

Ovule. Structure within the ovary that bears the egg.

Egg. Female cell, which (after fertilization) develops into the kernel.

Parts of catkins (male)

Catkin. Pollen-producing organ.

Pollen. Grains bearing sperm formed in anthers on catkins.

Pollen germination. The growth of a tube out of the pollen grain. This occurs when pollen is placed under suitable conditions such as on the stigmas of flowers.

Pollen tube. A tube bearing the sperm. In the process of germination, it grows down the style and into the ovary, where it transfers the sperm to the egg.

Pollination. Transfer of pollen from anther to the stigma of a female flower.

Fertilization. The union of sperm and egg to start the new generation (embryo or kernel).

Floral initiation and development

The life of a hazelnut nut begins with the formation of flowers more than a year before harvest. Most of the flowers form in buds at the axils of the leaves on the current season's growth.

The male catkins begin to form in April or May and begin to appear in June, although they do not reach maturity until the following December or January.

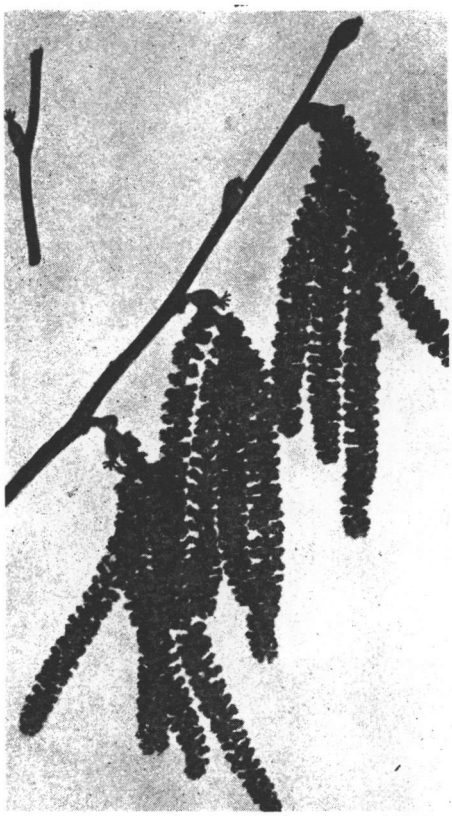

Figure 2.—Hazelnut flowers: *upper left,* female or pistillate; *lower right,* male catkins in bloom.

The female clusters begin to form in August and are first seen in late November or early December. January through February is the peak of the pollination season, but this varies somewhat according to weather conditions.

During this time, the female cluster appears as a bright red tuft of feathery stigmas projecting out of the bud scales. Within the bud scales are the lower portion of 4 to 16 individual flowers. Each flower consists of a pair of long styles with surfaces that are mostly stigmatic (receptive to pollen) and a tiny bit of tissue (0.25 mm or less) at the base.

The female hazelnut flower is very unusual. At the time of pollination, instead of having an ovary containing ovules with egg cells ready for fertilization, it has only the rudimentary bit of tissue mentioned in the last paragraph.

Within 4 to 7 days after pollination, the pollen tube grows to the base of the style, where the tip of the tube bearing the sperm becomes "walled off" and enters a long resting period.

Effective pollination stimulates the ovary to develop from this basal bit of tissue. It grows very slowly the first 4 months (until about mid-May) and then begins to grow rapidly, attaining 90% of its growth in the next 5 to 6 weeks.

By mid-July the shell is full size, and shell hardening is well under way. During the middle of this rapid growth period (mid-June), when the ovaries are 8 to 10 mm in diameter, the ovary becomes a mature organ containing egg cells.

The resting sperm becomes activated, secondary pollen tubes begin to grow, and fertilization takes place. This 4- or 5-month lapse between pollination and fertilization is one of the unusual features of hazelnut floral biology. (In most other plants, fertilization follows pollination by a few hours or a few days.)

After fertilization, the kernel develops rapidly, reaching full size in about 6 weeks (early August). From this time until harvest, maturation changes occur (an increase in oil content, for example). Towards October, the husk surrounding the nut dries and spreads open, and the nut falls to the ground.

Pollination

Pollinizer requirements

Hazelnuts are self-incompatible; they will not set nuts with their own pollen. Also, certain combinations of varieties are cross-incompatible (that is, pollen of some varieties is ineffective in setting nuts on certain other varieties).

Controlled pollinations made on Barcelona have demonstrated that certain compatible varieties such as Daviana, Hall's Giant, Butler, and Lansing set a normal nut crop, and that other incompatible varieties such as Montebello, Kruse, Camponica, Ennis, and Barcelona set only a very few nuts or none at all. It is essential to choose a compatible pollinizer variety.

Earlier recommendations to place three pollinizer varieties in an orchard were based on the extended period of time during which female flowers continue to appear. Stigmas are receptive from the time they first appear as a tiny red dot at the tip of the bud until they extend to their maximum length, wither, and fade. This takes place from late November until early March in some seasons.

Because each flower cluster is receptive to pollen for such an extended period, one pollinizer variety that sheds heavily during the peak bloom, or even somewhat past the peak, will provide adequate pollination.

Daviana and Butler shed most of their pollen in January and February. Commonly used in orchards as a single pollinizer, Daviana is successful in setting a normal crop. Since Ennis blooms late, a late pollinizer for it (such as Butler) is important.

Pollinizer spacing and placement

The standard placement of hazelnut pollinizers has been every third tree in every third row (3 × 3). This arrangement provides for more than 11% of the trees as pollinizers—which is too many trees.

Since most pollinizer varieties are less productive than Barcelona, or are of less value, or are different enough to significantly reduce the uniformity of the nut mixture, it is desirable to have the smallest number of pollinizers per acre that is necessary to provide adequate pollination.

Each Daviana catkin produces over one million functional pollen grains, and each tree usually bears several thousand catkins. The quantity of pollen usually is not a factor in determining the number of pollinizer trees, but their arrangement in the orchard could be.

For convenience of harvesting, some growers have planted solid rows of Daviana pollinizers in every tenth or twelfth row. This provides 10% of the trees as pollinizers, which is unnecessarily high. There is no evidence available to support or discredit this practice, but solid rows of pollinizers create a situation where certain lots of nuts have a very high percentage of pollinizers. This has been considered an inconvenience by nut handlers.

Pollen grains can be carried great distances by the wind. The density of the pollen cloud decreases with the distance from the source. Thus, distance is the most important consideration in pollinizer placement. The most logical placement of pollinizer trees would be one in which they are dispersed throughout the orchard rather than in solid rows, to use the wind to best advantage.

It was found that in 25 × 25 foot plantings, pollinizers every third tree in every third row, or seven per acre, provided an abundance of pollen.

In a 20 × 20 foot orchard, pollinizers every sixth tree in every third row, staggered (diamond arrangement) would provide six pollinizers per acre, which is adequate.

The greatest distance to a pollinizer tree would then be 60 feet. This 6 × 3 arrangement is also considered adequate for spacings closer than 20 × 20 feet.

Blanks, brownstain, and developmental dropouts

Blank formation

Potential yields of all varieties are reduced by varying percentages of blank nuts. A blank nut consists of a shell without a sound kernel. Blanks occur when pollination stimulates the shell to develop, but the kernel fails to develop normally. Either it fails to grow at all or it starts to grow and then aborts, especially in the early stages of growth.

However, in some cases, kernels may grow to over half their expected size and then shrivel. These nuts also are culled out as blanks although they do hold kernels.

Lack of pollination is never the cause of blank nuts because a flower that is not pollinated simply does not develop beyond its tiny size at pollination. When pollen is withheld from female clusters by covering them with bags, the clusters dry and fall off by late April or early May.

Factors that contribute to high percentages of blank nuts are not definitely established. Some evidence suggests that insufficient soil moisture in midsummer results in a higher percentage of blanks. Other indications are that the pollinizer variety or tree nutrition may influence blank production. There also appear to be varietal differences in blank production.

Brownstain

Brownstain is a disorder that causes severe crop loss in some seasons, usually about every 8 to 12 years. The cause is not known. Brown stains are seen on the sides of nuts in early July. Affected nut clusters often drop from the tree in July and August.

Many affected nuts are blanks or only partially filled. Among the main commercial varieties, only Barcelona has a serious brownstain problem. Abandoned or partially neglected orchards have less brownstain than well-maintained orchards.

Flower cluster losses

Another yield-limiting factor that is even more serious than blanks is the early dropping of female clusters. In the Barcelona variety, this amounts to 35 to 50% of the clusters produced on the tree.

The majority of flowers in these clusters have been pollinated, and development has progressed for a few months at the normal slow rate before growth is arrested. Although the individual flowers are larger (1-2 mm diameter) at their base than at the time of pollination (0.25 mm), the clusters are still so small that their dropping is not conspicuous in the orchard. Part of the flowers in clusters that do hang on the tree, because of the normal development of at least one nut, are also subject to arrested growth.

A close examination of nut clusters during summer will disclose a few tiny, undeveloped flowers embedded among the fleshy husks. The potential loss in the Barcelona variety due to these "developmental dropouts" amounts to 75 to 85% of the total individual flowers produced by the tree.

You can increase your final percentage of nut set with a single spray of Solubor (sodium pentaborate), using 2 pounds of product per 100 gallons of water (8 pounds per acre), applied in late May. Foliar-applied boron has increased nut cluster set by 33%.

The best time to spray depends on whether the season is early or late. Do not apply more than 1 pound of actual boron per acre (excess boron can be toxic).

Growing and selecting planting stock

Method of propagating

Hazelnuts are propagated by simple layerage (rooting a plant part while that part is still attached to the parent plant). The suckers of an orchard tree or the stems in a stool bed are bent in an S-shape, so that one bend is under ground where roots can form on it. The tip end of the stem is left above ground to form the new tree (see figure 3).

To begin the layerage procedure, loosely cultivate the soil around the stool. Next, select a stem from the previous season's spring growth, about the time it begins leafing out. Strip the leaves from all but the apical 12 to 18 inches of the stem. Bend the stem and slightly twist it over to the side as you set it in the ground to a depth of a shovel blade. Hold it in place by firming soil on top of the buried section.

Roots form on the underground portion of the stem during the summer. In autumn, after leaf fall, cut the layered stems from the stool and dig for pruning and grading.

Trees grown from simple layerage, with the roots originating in a short space (2 to 4 inches) along the stem, will produce fewer suckers after planting. The better layered trees do not have a crook at their base (see figure 4).

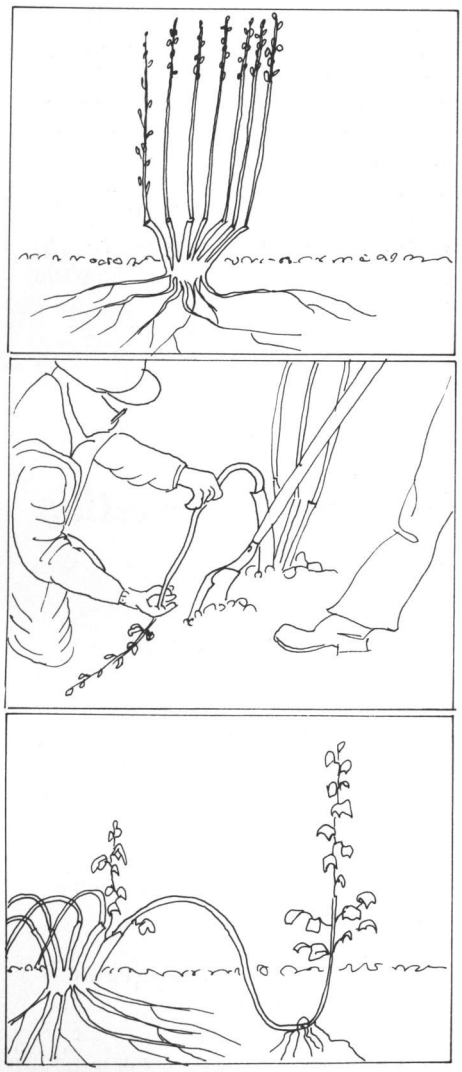

Figure 3.—In propagating hazelnuts by simple layerage, the stool produces long shoots, which are bent down and covered with soil in the spring. These stems produce roots and form marketable trees by summer.

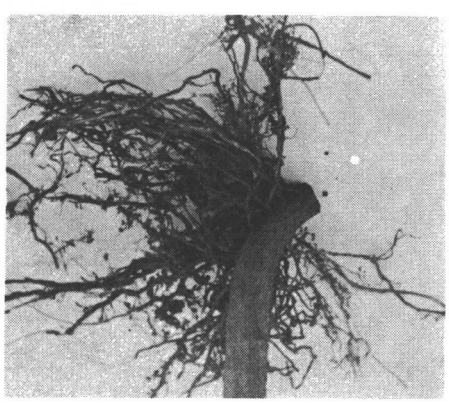

Figure 4.—A strong-rooted Barcelona layered tree, just removed from the stool and ready for planting.

Propagating from suckers

Additional nursery trees can be produced from suckers arising from the base of existing orchard trees. When they are 2 to 3 feet long in early summer, place a wire or bag-closure twist around the base of the sucker.

For another way to increase rooting, apply some indolebutyric-acid-based rooting hormone to the surface of the first few inches of stem. Cover the suckers with moist barkdust, sawdust, or leaf mold to a depth of at least a foot.

You can hold this mulch in place with a roofing paper collar encircling the tree trunk outside of the suckers. Most of the suckers will root by the following December. After harvesting, they should be grown in a nursery with irrigation for a year before being planted in the orchard.

Grafted trees. A new development in hazelnut growing involves the use of nonsuckering rootstocks and grafted trees. Research aimed at finding superior rootstocks for hazelnuts is under way. Callusing of hazelnut grafts depends on temperature; temperatures over 70°F are required for a high level of success.

Delay grafting in the field, therefore, until the average daytime high temperatures are in that range. Scionwood must be cut in midwinter when it is still dormant, and held in cold storage until then.

Whip-grafting with two-bud scions has been successful. Tie it with a ⅜-inch-wide grafting band, being careful to overlap to exclude air. Paint the cut tip of the scion with elastic grafting compound. It may also be helpful to paint the scion white to keep it cooler.

Don't paint the elastic band. Grafting in the dormant season can be accomplished using rooted layers and a specially constructed hot-callusing tube.

Selecting planting stock

The best quality tree gives the best performance. Hazelnut nursery stock should be at least ½ inch in diameter at a point 6 inches above the soil line. Although hazelnut trees often are sold by height, caliper or diameter provides a more reliable indication of the stored food reserve of a nursery tree.

Nursery trees are dug in early winter, after leaves have fallen and the plant tissue has hardened. The roots of dug trees are "heeled" into moist sawdust or soil so the roots will not dry out or freeze. Order and plant trees early for best results.

Orchard design

Intercropping with hazelnut trees

One way to get profitable returns from an orchard much sooner, while avoiding the usual drawbacks of intercropping, is to make a high-density planting. For example, you could plant trees 10 × 18 feet and thin to a 20-foot triangle or an 18 × 20 rectangle after 10 years or when the trees begin to crowd.

Since the yield per tree in a closely spaced orchard is nearly the same as on a widely spaced orchard for the first 5 to 6 years, yield per acre goes up in proportion to the increased number of trees.

Once the trees begin to crowd, it is essential to prune back the temporary trees to allow the permanent trees to expand in a fairly normal pattern. An average yield for 6-year-old hazelnut trees is about 5½ pounds. Table 2 shows yield per acre for different tree populations, assuming a 5½-pound yield per tree at 6 years.

Table 2.—Effect of tree population on per-acre yield of hazelnuts (sixth year)

Spacing arrangement (feet)	Trees per acre	Yield per acre (pounds)
10 × 18 rectangle	242	1,331
20 × 20 square	108	594
15 × 15 square	194	1,067
18 × 18 triangle	155	853

With the change from cultivation to flailing, a rectangular arrangement of trees has become the most popular. Spacings of 10 × 20 feet (218 trees/acre), or 12 × 18 (201 trees/acre) allow for thinning to a triangle of approximately 20, 21, or 22 feet.

Although a herbicide-treated strip of soil down the row reduces the need for cross-flailing, cross-flailing helps to eliminate grooves in the soil surface.

Arrangement of permanent trees

Trees on deep, medium-textured bottom land will be larger when mature than trees on soils that are shallow, sandy, or clayey. Consider these factors when you plan final tree spacing.

There are three basic ways to arrange trees in an orchard: square, rectangle, and triangle. The square is the least efficient in terms of numbers of trees per acre at a given spacing; the equilateral triangle is the most efficient. Table 3 illustrates this point.

Table 3.—How tree arrangements relate to trees per acre

Dimensions (feet)	Arrangement	Trees per acre
20 × 20	Square	108
18 × 22	Rectangle	110
20 × 20	Equilateral triangle	125

The 15 × 15 foot square, with 194 trees per acre, has been a popular spacing in the past. It is most suitable for soils with good water-holding capacity but too close for shallow or sandy soils.

The closeness of the trees presents several difficulties in management (for example, very tight turns with equipment). Furthermore, standard equipment, especially sweepers, doesn't fit this spacing. The 15 × 15 foot square requires very intensive management.

For orchards with good soils and good management, the 18 × 18 foot triangle with 155 trees per acre is the best permanent spacing, and it will accommodate standard-sized equipment.

It is possible to work the orchard in three directions. This permits the removal of grooves in the soil surface, which may form when the orchard is always worked in a single direction. The principal disadvantage is that it is difficult to design hazelnut interplants within this arrangement.

The 20 × 20 foot square, with 108 trees per acre, is adaptable to a variety of soils and situations. It will provide an easily managed orchard for inexperienced growers. It is most attractive to growers who contract harvesting or other operations. Disadvantages are lower yield than at closer spacings and a longer period of time to reach commercial production.

The 10 × 18 foot rectangle, with 242 trees per acre, can be thinned to form a triangle 20 × 20.6 feet by removing every other tree. Early yield is the principle advantage of this arrangement.

Inability to cross-flail, higher costs for trees and tree maintenance, and the cost of tree removal at thinning time are principal disadvantages. Only those growers who are willing to provide intensive management should use this system.

Establishing a new orchard

Staking out the orchard

The first consideration in laying out an orchard is to establish base lines—two or more lines if you plant your trees on the square or rectangle system, one line if you lay out your orchard on the triangular system.

For the square system, select one side of the field from which you can lay off a line parallel to the fence or road. Use this side as the base line AB (see figure 5).

With a tape or other means, lay out 60 feet on AB. Then, to lay out line AC, approximate a right angle to base line AB, measure off 80 feet, and strike an arc using A as a pivot point.

From point B, with a line 100 feet long, strike another arc intersecting the previous arc. The point at which the arcs intersect will be D, the point through which you locate line AD permanently. AD will be at a right angle to base line AB.

It is generally an advantage to lay off another base line at the opposite side of the field from AD and at right angles with the base line AB.

For laying off by the square, rectangle, or hexagonal systems, obtain a set of wires the same length as the distance apart that you plan to set out the trees. Make the set of two wires, with one end of each wire joined together on a small ring. Fasten the free ends to two separate rings.

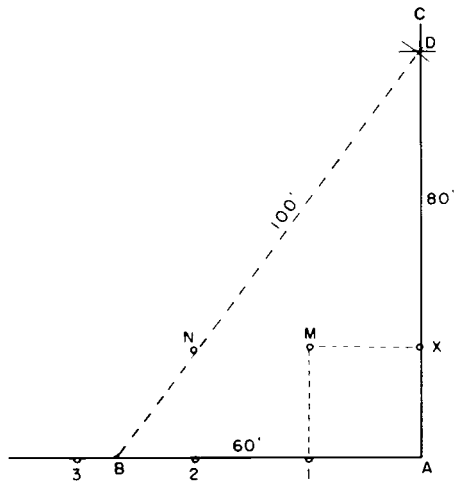

Figure 5.—Laying out the orchard by the square method.

After staking off the base line at the intervals you've chosen for the trees, start staking the tract. By placing the two ring ends of the wire over stake 1 and stake X, and drawing the common center ring away to make the wires taut, you can then place a stake at point M (figure 5).

Next move the wires so that you can place the free rings over stake M and stake 2. Then place a third stake at the common center ring at point N.

You can carry on this process indefinitely, backward and forward across the field, until you've completely staked out the field.

Hold the wires in the same plane each time and draw them up to the same degree of tautness. Occasionally check by sighting or by remeasuring wires to straighten out rows, especially if the field is uneven.

Other methods of staking out orchards include using a transit and sighting from two sides of the field with someone to help set the stakes at the points desired. Overall, wire is probably the quickest and simplest method of staking level land. Often a single long wire with soldered points indicating where stakes are to be set is used alone.

The triangular or hexagonal system of planting requires only one base line (figure 6). Measure the base line off

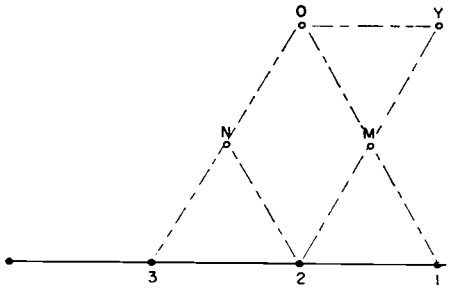

Figure 6.—Laying out the orchard by the hexagonal method.

into the regular intervals at which you will plant trees and drive stakes at each point.

Using the wire set, place the rings over stakes 1 and 2 (figure 6), draw the wires tight, and set a stake at M. Then place the rings over stakes 2 and 3. Now place a stake at N, and so on throughout the field.

If you use this method, you will need to fill out the side of the field. By placing one free ring over M in the second row and O in the third row, you can place a stake at Y so the third row will be lengthened out to line up with row 1.

Using a planting board

A planting board may be of value to set trees in line after staking out the field. This board is 3 to 4 feet long with a notch at each end and another notch along one side in the exact center.

Before digging the tree hole, place the planting board so that the stake, which marks where the tree will be, is cradled in the center notch. Place a stake in the notches at each end of the board and remove the center stake and planting board.

After you dig the hole, place the tree in the hole and replace the planting board in the original position over the two end stakes. Line the tree trunk up in the center notch to retain the original staking alignments. The board must face the same direction for each planting.

Planting the trees

Plant the trees in early winter, as soon as possible after you receive them from the nursery. Don't let the tree roots dry out before planting. The earlier a tree is planted, the more chance it has to develop a working root system before it leafs out in the spring. Root growth is active in January and February, when soil temperatures are 40°F or above.

Prune off the ends of broken roots and remove any of the original layered wood remaining below the main area of rooting.

Dig holes for the trees 18 to 24 inches wide and 10 to 12 inches deep. Digging in wet ground with a power auger may cause compaction on the sides of the holes. If this happens, break down the edges of the hole to eliminate the compacted area and partially fill the hole with soil.

Spread the tree roots out and press them down into the bottom of the hole. Plant the trees so the top root is 2 to 3 inches below the soil surface. Tamp the soil firmly around the roots to exclude air pockets.

Pruning at time of planting

After you plant the trees, head back the tops, leaving a trunk 30 to 36 inches in height. This top reduction should offset the root damage suffered by the tree during digging and handling. In transplanting, a considerable portion of the roots are lost, and the water-absorbing capacity of the plant is reduced.

If trees are not topped, their root systems may be unable to provide sufficient moisture to replace that lost by transpiration. Consequently, the trees will be retarded in growth or may die. If trees are branched, cut the laterals back to a few buds, or remove all laterals and treat the tree as a headed whip.

After pruning each tree, sterilize pruning tools with rubbing alcohol to prevent the spread of filbert blight.

Protecting against sunburn

In the first few seasons after planting, the trunks of young hazelnut trees are easily sunburned, especially near the surface of the soil or mulch. Painting the south side of the trunks once per season for the first 2 years, with a 50% dilute solution of white exterior latex paint and water, will provide ample sun protection.

Be sure to paint the trunk so that the reflective white surface is at or below the mulch level. The mulch will often settle, leaving an unpainted section of the bark near the soil line—and this section will be more susceptible to sunburn. Don't use lead base paints.

Tree protectors tied loosely around the trunks will also provide sufficient protection from sunburn. Some translucent plastic wraps or highly reflective white collars may actually increase the heat injury to trunks.

Mulching. A sawdust mulch about 3 to 4 inches deep around young trees both suppresses weed growth and preserves soil moisture. In trials, young trees that were mulched but not irrigated grew nearly as rapidly as irrigated trees. Black plastic mulch is even more effective but may not be as economically practical. Organic mulches may reduce the effectiveness of certain herbicides; therefore, herbicide applications should precede mulching.

Managing a hazelnut orchard

Nontillage

In the past, weed control in hazelnut orchards was accomplished exclusively by cultivation. Most hazelnut growers have changed from cultivation to flail mowing and use herbicides in the tree row.

Flail mowers (figure 7) are constructed to mow weeds as close as ¼ inch from the soil surface. Flailing is started in spring as soon as the ground is dry enough to accommodate a tractor with wide, high-flotation tires without making ruts. Usually this occurs in March before ground vegetation is 6 inches high.

After the winter rains subside, winter annual weeds die out—but the more competitive, drought-resistant summer weeds germinate and grow.

Figure 7.—A flail mower controls weeds mechanically as it moves between the rows of hazelnut trees.

Cover crops are rarely planted; usually, volunteer weeds are simply allowed to grow. A few growers, however, seed subterranean clover as a winter cover crop and clip it close in spring. When clover is planted, gophers tend to increase. Control of gophers is especially important in an orchard planted with clover (see "Gophers and moles," page 15).

Early flailing and a combination of preemergence residual herbicide and contact herbicide in the tree row will help reduce weed competition. Always apply herbicides according to label directions.

The nontillage system of soil management is popular because it eliminates most of the ground preparation work necessary for harvest (figure 8). The tillage method of weed control does not. Usually four to six flailings per season give satisfactory weed control. Sometimes, even with flailing, it is necessary to float the surface before harvest to fill in small depressions.

Studies have shown that soil moisture levels in the trees root zone under flailing do not differ appreciably from those under clean cultivation. The soil in the top 3 to 6 inches is usually drier under flailing than under cultivation, but at lower depths there is no difference.

The earthworm population increases under flailing if moisture is preserved. Earthworm castings can be a nuisance during harvesting. However, the vertical tunnels the worms make greatly increase water penetration and drainage, so that harvesting can be resumed soon after a heavy rain.

Under flailing, soil erosion is mainly confined to the herbicide-treated strip. These strips should run across rather than with the slope.

Before you can begin flailing, your orchard floor must be smooth and even. Remove mounds of soil around the tree trunks (you may need a leveling device). It is easiest to do this leveling before the trees are planted. It may be best to delay flailing as your primary orchard-floor management method until the trees have been in the ground 1 or 2 years.

Figure 8.—Nontillage practice allows harvest without bogging down in mud.

Cultivation

Although most hazelnut orchards are currently managed with nontillage, some operators prefer to cultivate. Cultivation is mechanical weed control and conserves moisture only as it succeeds in killing weeds or cover crop. When cultivating, remember that most hazelnut roots are in the top foot of soil, where they are easily pruned off by implements.

Limit depth of tillage to 4 inches for working down the cover crop and reduce to 2 inches for the balance of the tillage season.

As soon as weeds are under control, prepare tilled soil for nut harvest by rolling to smash clods and dragging to smooth the area. This is a dirty, expensive job (one you can avoid almost entirely if you use flail culture).

Intercropping

It is a faily common practice to plant another crop between the rows of trees for the first few years after planting. When the crop is irrigated, this can actually help the trees grow in the early years. Strawberries and beans are common intercrops in irrigated situations.

Under nonirrigated conditions, any intercrop usually is detrimental to growth of the young trees, sometimes extremely so. Both intercrop and weeds compete with the young trees for moisture. The result is poor growth and a relatively high rate of mortality.

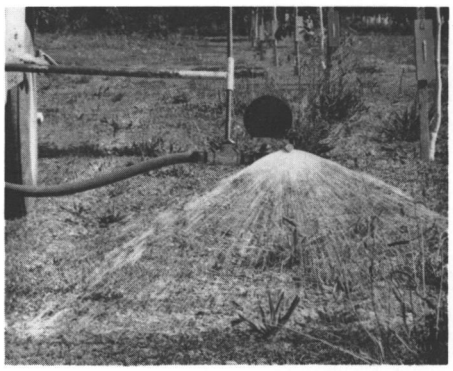

Figure 9.—Low-pressure herbicide sprayers apply herbicide in a strip down the row. With this plan, the orchard doesn't have to be designed to allow cross-flailing.

Weed competition. Some herbicides can be applied several weeks after planting; others carry a precaution against their use on trees under 3 years of age. *Read the label carefully* to determine which herbicides you can safely use during your orchard's first few years. See figure 9. A good herbicide program in the tree row, with flailing between rows, provides the best protection against weeds.

In wet years, weed growth may become so rank that it will prevent or retard normal harvest operations. If you anticipate this, use some late-season chemical weed control.

Since herbicide registrations change from year to year, no chemicals are listed here. Contact your Extension agent for suggestions.

Cover crops

For orchards with tillage programs, annual winter cover crops are necessary to prevent soil erosion in most cultivated orchards. The growing cover crop slows runoff and aids penetration of rainfall or irrigation water. Cover crops reduce the soil compaction caused by movement of vehicles in the orchard.

Willamette vetch, hairy vetch, oats, winter wheat, or winter barley make good cover crops. Sow these immediately after nut harvest. Managing native populations of subclover or annual bluegrass also provides good cover. Sometimes there are enough volunteer weeds to serve as a cover crop, to help prevent erosion and reduce soil compaction.

Training and pruning

The objectives of tree training, in the first and second years after planting, are totally different from those used in pruning mature orchards. The main objective of training is to develop a strong system of major scaffold limbs.

Select three to five major limbs in the first 2 to 3 years. Thereafter, very little pruning is required for several years. Heavy pruning of young trees (to promote cultivation close to the trunks) is detrimental—it prolongs the nonbearing period. Pruning also forces sucker growth to develop from wounds; this growth fills in the center of the tree and shades the other limbs.

Pruning of mature trees helps to maintain a high level of production of large nuts and discourages the alternate-bearing habit of the hazelnut. Tree condition is the best indicator of the need for pruning.

It is time to prune when:

1. a reasonable fertilizer and soil management program fails to produce an average of 6 inches or more of annual terminal growth;
2. numerous dead twigs appear in the tree center and lower branches;
3. moss and lichen growth develops throughout the tree; and
4. the outside rows show more vigor and better foliage color than inner tree rows.

This may come as early as 12 years after planting in some orchards or as late as 20 to 25 years in others (figures 10a and 10b).

Experiments have shown that yields are reduced the first year after heavy pruning, but they are substantially increased in the second and later years. It takes considerably less time to cut 50% of the bearing surface from 20% of the trees than it does to remove 5 to 8% of the bearing surface on all of your trees each year.

Since yield is slightly reduced the first year after pruning and since heavy pruning rejuvenates the tree for several years, it seems advisable to prune a portion of your orchard each year.

Remove as much of the unthrifty, moss-covered wood as possible, leaving a large scaffolding on which to grow new fruiting wood. Trim out the centers and shorten the low laterals (this also will make it easier to move equipment in the orchard). Remove suckers that grow up through the canopy from lower limbs, unless you can use these suckers to fill an opening in the top of the tree.

Figure 10.—*Left:* Heavy pruning has opened up this hazelnut tree's center and has left a large scaffolding for new fruiting wood. *Right:* After one growing season, this heavily pruned tree shows excellent upright growth.

In general, thin the tree so that light penetrates to all remaining parts. Cut limbs flush with the trunk wherever practical (stubs do not heal over, and they provide entry for wood rot organisms).

Mechanical side hedging with gang saws has increased in recent years. This is a rapid, economical way to remove large amounts of wood from an overgrown orchard. Yields have increased in some older orchards after side hedging. However, production did not increase in test plots with young trees (apparently, they were in less need of pruning).

Side hedging would most likely benefit an older orchard, where the treetops have grown together, more than a younger orchard where this condition hasn't yet developed. Regrowth is often so rapid that the space between trees created by hedging is filled in after two seasons.

With hedging, all new growth becomes concentrated along the plane of cutting. Growth in other parts of the tree may be reduced unless you do some followup hand pruning. Mechanical topping reduces yield for at least the following two seasons; but after that, yields increase.

Wound dressings

There is no conclusive evidence that wound dressings help to prevent wood rot following pruning. To reduce the danger of wood rot after pruning, make cuts in smaller wood high in the tree, and avoid cutting close to the trunk.

Sucker control

A sucker is a shoot originating from low on the trunk or from roots near the trunk.

All hazelnut varieties and all rootstocks except the Turkish hazel *(Corylus colurna)* will sucker to some degree. If you promptly and carefully remove suckers during your first few years after planting, you'll greatly reduce the labor you'll need for this operation in later years!

The general-purpose herbicide 2,4-D is now registered for control of suckers in hazelnuts. Spray suckers thoroughly when they are 6 to 9 inches tall. Spray when needed, April through August, but not more than four times. Read the product label carefully—and follow the instructions.

Dinoseb general weed killer with oil has been used successfully for sucker control. However, it may damage the bark of young trees, so don't use it for the first 5 years after planting; after that, be careful to minimize its contact with the bark. Paraquat has also been used successfully but without the bark damage associated with Dinoseb.

Orchard nutrition

New orchards

Soil sampling and testing the fields you expect to plant to hazelnuts is recommended. Applying and incorporating certain nutrient elements into soil (such as K and Mg) is done best before planting.

Potassium (K). Broadcast it and plow it under when you prepare the land for planting (table 4).

Table 4.—Proper use of potassium

If OSU soil test for K reads (ppm)	Apply this amount (lb/acre)[a]	
0-75	300-400	250-330
75-150	200-300	165-250
Over 150	None	

[a] $K_2O \times 0.83 = K$.

Magnesium (Mg). Broadcast and plow under Mg, too, when you prepare the land for planting.

If the OSU soil test for Mg is less than 0.5 mg per 100 g of soil, apply 1.0 ton/acre of dolomitic limestone. It acts in a similar manner to ordinary limestone in correcting soil acidity. The need for applying Mg is usually greater where K and calcium levels in the soil are high.

Lime. If liming is needed before planting, it is best to mix it into the soil to as great a depth as possible. Applying lime to the surface of established orchards without soil incorporation has also been effective. To determine if you need liming, take soil samples and use your OSU buffer test as shown in table 5.

Table 5.—Proper use of lime

If the OSU buffer test for lime reads	Apply this amount of 100-score lime initially (tons/acre)
below 6.1	2-3
6.1-6.4	1-2
over 6.4	0

Do not apply fertilizers of any kind in the tree hole. Fertilization at planting time may burn the newly forming roots, retard growth, and increase tree mortality the first season. Young nursery trees generally do not respond even to "slow release" fertilizers applied at planting time.

Nitrogen (N). Apply N only after one growing season has passed. Young trees should grow 18 to 30 inches annually (table 6).

Table 6.—Proper use of nitrogen

Age	Apply this amount (lb N/tree)
Planting to 1 year	None
2-5 years	¼-⅓
6-7 years	⅓-½
8-10 years	½-¾

Mature orchard nutrition

In fertilizer experiments, hazelnut yields have been increased only by applying nitrogen, potassium, magnesium, and boron. Increased yield has not been observed with other elements such as phosphorus or zinc.

If other factors aren't seriously limiting, leaf size and color and shoot growth reflect the tree's nutritional condition. Short shoots and small, pale leaves leaves may indicate a nitrogen deficiency.

With potassium deficiency, leaves are also small. The husks surrounding the nuts are abnormally short, and leaves may start dying at the edges in severe potash deficiencies.

Fertilizer needs and application

Leaf analysis indicates which elements are present in adequate, deficient, or excessive amounts. Take a sample consisting of 50 leaves, 5 from each of 10 trees that are representative of the orchard or of the troubled area.

Pick leaves from the middle of nonbearing shoots of average vigor, located at about breast height around the periphery of the tree.

If they are very dirty, wash them briefly in cold water with a few drops of detergent, rinse, and spread out to dry. Sampling can be done any time in August. Predictions of fertilizer needs for established orchards based on soil tests alone are usually not reliable.

Suspect nutrient deficiency if you can't identify the cause of poor tree performance as one or more of the following:

Lack of pruning	Poor soil drainage
Winter injury	Disease
Physical injury	Insects
Winter freezes	Rodents
Poor pollination	Shallow soil or
Deep cultivation	limited moisture

Nitrogen (N). Table 7 is a leaf-analysis guide for applying N to mature trees with an average crop.

Applying N in early fall could increase danger of winter freeze

Table 7.—Leaf-analysis guide for N application[a]

	% leaf N in August	Apply this amount of N lb/tree	lb/acre
Under	1.8 (severe deficiency)	3	300
	1.8-2.2 (deficiency)	2	200
	2.2-2.5 (optimal)	1	100-150
Over	2.5 (excess)	None	None

[a] In a year of heavy cropping, N levels will be about 0.2% higher.

damage and loss of N by leaching or denitrification. For these reasons, N is usually applied between February 15 and March 15. Adjust rates according to results of application in previous years.

For trees that have not yet grown together, the best way to use the fertilizer is to place it in the area starting halfway between the tree trunk and the drip line.

Phosphorus (P) deficiency has not been found. Hazelnuts use little P and are able to store P in buds and twigs for later use.

Potassium (K) deficiency is common in Oregon hazelnut orchards. Since K applications tend to reduce magnesium uptake, don't apply K unless leaf analysis indicates a deficient or borderline level.

Table 8 is a leaf-analysis guide for applying K to mature trees with an average crop.

K levels decline in a year of heavy cropping. The K content of fertilizer is expressed as the oxide (K_2O) on fertilizer labels. Multiply K_2O by 0.83 to convert to K.

Place K in a concentrated band about 6 inches wide on the soil surface, about halfway between the trunk and the drip line.

Table 8.—Leaf-analysis guide for K application

	% leaf K in August	Apply this amount of K_2O lb/tree	lb/acre
Under	0.4 (severe deficiency)	10-12	1,000-1,200
	0.4-0.6 (deficiency)	6-10	600-1,000
	0.6-0.8 (borderline)	4- 6	400- 600
Over	8.0 (optimum)	None	None

Apply muriate of potash (KCl) in fall or before mid-February to avoid chloride toxicity. You can eliminate chloride burn by using the sulfate (50% K_2O) or nitrate (44% K_2O and 13% nitrogen) forms of potash.

Potassium levels often do not increase until the year following application. A single application is usually effective for 2 to 5 years. Lesser amounts banded annually in exactly the same location may be as effective as a single large dose. On some sites, even repeated banding of K fertilizer has failed to increase leaf K or growth.

Boron (B). One annual spray of sodium pentaborate (Solubor or Boro spray) has increased hazelnut set as much as 33.5% where leaf analysis has indicated deficient boron levels. Apply about 1 pound of actual boron (4.88 pounds of Solubor) per acre between May 15 and May 30. The amount of water used in commercial orchards has varied from 30 gallons to 300 gallons per acre with equal effectiveness, provided thorough coverage was attained.

Repeated annual boron sprays may build B up to a toxic level after several years. When B levels in the leaf reach 200 ppm, stop the applications until the leaf B levels decline below 100 ppm.

Insects

The filbert worm is the most important insect pest. Leafrollers, aphids, and filbert bud mites are also serious pests.

Normally, the filbert worm is controlled with Sevin or Guthion applications about July 10 to 15, with a repeat application in 3 weeks in heavily infested orchards.

Detailed information on control of insect pests is available from your Extension agent.

Diseases

Orchard sanitation

Health authorities emphasize sanitation of nut crops. Contamination from animal manure is the principal concern. For this reason, and because you harvest the crop from the ground, it's not advisable to use animal manure in nut orchards.

Bacterial blight

Commonly known as filbert blight, this is the most important disease of the hazelnut in Oregon. Its prevalence and destructiveness varies with the season. The disease is usually very prevalent after heavy fall rains. The disease is usually more of a problem when it's preceded by a fall season with heavy rains (see figure 11).

The most serious phase of filbert blight is trunk girdling and killing of trees up to 5 years of age. Trunks of older trees are seldom infected, but buds and nut-bearing twigs in the tops often are killed, reducing yield.

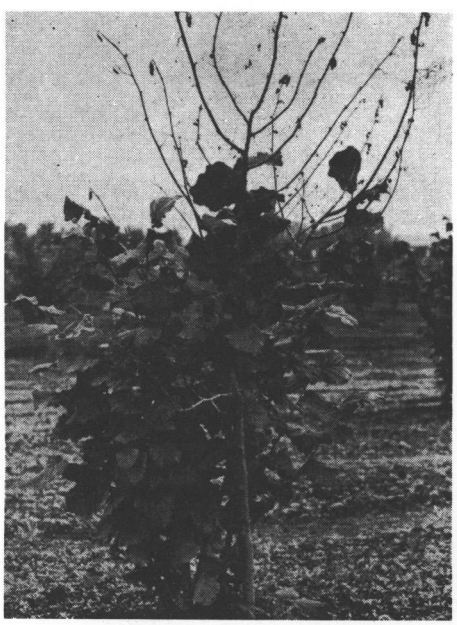

Figure 11.—Bacterial blight kills buds and twigs, substantially reducing bearing area.

The disease is seldom found on the nuts or in the roots. You can significantly reduce bud and twig infections caused by bacterial blight, in both young and old orchards, by sprays or dusts.

Sprays include Bordeaux 6-3-100 or tribasic copper sulfate (6 pounds per 100 gallons of water) and Kocide 101 (4 to 6 pounds per 100 gallons of water). A compatible wetting and sticking agent will increase effectiveness of these spray mixtures.

In a normal season, one spray application in late August or early September (before the first heavy fall rains) is usually enough to give commercial control of filbert blight. In seasons with heavy and prolonged rainfall during the fall and winter, a second application may be necessary when about three-fourths of the leaves are off the trees.

Wounds from pruning, leaf stripping, tillage equipment, frost damage, and other causes provide ready entry to blight organisms. Avoid them or treat them promptly.

Sterilize pruning tools and exposed surfaces with a reliable disinfectant like 70% denatured (rubbing) alcohol. Sponge the exposed surfaces with the disinfectant. Disinfect pruning tools between trees.

Use herbicides and pesticides safely!

- **Wear** protective clothing and safety devices as recommended on the label. **Bathe or shower** after each use.
- **Read** the herbicide label—even if you've used the herbicide before. **Follow closely** the instructions on the label (and any other directions you have).
- **Be cautious** when you apply herbicides and any other pesticides. **Know** your legal responsibility as a herbicide applicator. You may be liable for injury or damage resulting from herbicide use.

Eastern filbert blight

Plant quarantine has kept this fungus disease from western hazelnut orchards for the past 50 years. Now it has been found in Clark and Cowlitz counties of Washington and Columbia County, Oregon. The disease can kill entire orchards and seems likely to spread if not identified and contained (figure 12).

This disease is caused by a fungus, *Anisogramna anomala.* Don't confuse it with the more common bacterial blight of hazelnuts. The fungus attacks stems and twigs of the cultivated European hazelnut grown in the Pacific Northwest, as well as the wild American hazel of the eastern U.S. It has not been reported attacking the wild beaked hazel of the Pacific Coast.

The fungus attacks the new twigs first, but later it involves the large limbs. Eventually, most of the tree above the soil line is killed. The pollinizer variety Daviana appears to be most susceptible and may be the first tree in an orchard to show symptoms of the disease.

The fungus infects the bark, which turns dark in color. Twigs and branches become girdled, and the leaves beyond the infected area may wither. At this point, symptoms are similar to those caused by most canker-producing organisms.

Later, the spore-producing pustules of the fungus appear in lines on the dead bark. Pustules are oval and distinctly raised above the surface of the bark. Each pustule is about ⅛ inch wide and ¼ to ⅓ inch long, appearing in almost straight rows lengthwise along the branch.

Spores of the fungus are spread in the orchard by wind and rain. The disease apparently spreads over greater distances by wind-blown spores. It may also be carried to new areas on leaves, twigs, or infected wood.

Control. The number of new infections per tree has been reduced by the fall and winter application of copper. Either Bordeaux 8-8-100 or Kocide 4 pounds/100 may be applied after harvest and again in January.

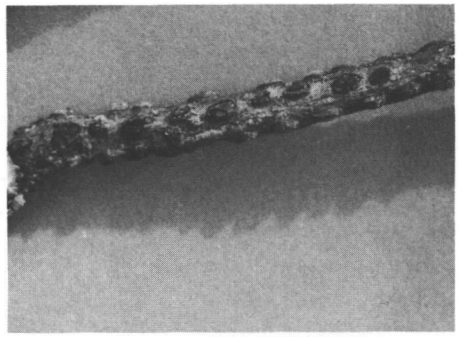

Figure 12.—These hazelnuts shoots show pustules of eastern filbert blight.

Animals

Blue jays and squirrels

Blue jays and squirrels often congregate in large numbers around hazelnut orchards. They consume large quantities of nuts.

Shooting is a common control method, but it's costly and time-consuming.

Trapping with ordinary steel traps made for rodents has been fairly successful. Traps are more effective when attached to the top of posts (short posts for squirrels, long posts for blue jays). Prop the posts against trees along the outer row of the orchard. Nuts on the trees are the only bait.

One grower uses an electric fence to keep squirrels out. A chicken wire fence 20 inches high is topped off with a slanted cover that exposes a gap almost large enough for squirrels to pass through. The top of this surface entrance is strung with electric wire, shocking rodents as they attempt to climb over the fencing.

Deer damage

Deer are particularly serious pests of young hazelnut trees in orchards next to wooded areas. So far, no satisfactory answer to deer damage has been found. Deer fencing around the entire orchard is the most reliable solution, but it's expensive. Special hunting licenses may be obtained for some locations.

Chemical repellants have been partially successful in deterring deer. Bags of blood and bone meal hung on the trees are the most commonly used repellants.

When replaced every 2 or 3 months, they have been relatively successful. Several chemical repellants on the market have been successful in some instances. As the tree grows, the new foliage needs protective treatment. (Keeping dogs in the area will also help.)

Gophers and moles

A single gopher may kill a dozen or more trees in one season. Usually, gophers are attracted to the orchard by the succulent roots of the cover crop. When the cover crop is turned under, gophers turn their attention to the trees. Gopher activity can be recognized by the crescent-shaped mounds of earth with either an open or a plugged hole.

Three practical methods of controlling pocket gophers are toxic baits, burning sulfur with a weed burner down the hole, and trapping. Over large or heavily infested areas, baiting is the fastest and most economical method of control.

Early spring baiting, before the young are born, is the most satisfactory. Bait only where there is fresh gopher activity. Stragglers that are not poisoned will continue to throw up fresh mounds (trap these individuals).

For the sulfur-burning method, place several tablespoons of sulfur in a recently made burrow, after you have removed the plug of soil—even better, do it before the gopher plugs the hole. Then light a propane weed burner and train it on the sulfur, burning it and blowing the fumes down the hole.

In recent years, a mechanical device known as the pocket gopher burrow builder has been developed. Pulled behind a tractor, it builds an artifical burrow at an adjusted depth and at the same time drops grain bait at regulated intervals.

It's being used very successfully for the control of all pocket gophers that will accept grain baits. No machine has yet been produced to use the vegetable bait needed for the large Willamette Valley pocket gopher.

Moles don't eat trees, but they make mounds that interfere with mechanical harvesting. Mole mounds are circular with a hole in the center. A mole trap is the only practical way to kill moles.

Meadow mice

The usual damage caused by meadow mice is girdling of both roots and stems. The mice depend on cover for protection, and damage usually occurs when cover exists (heavy sod, cover crop, litter, or snow).

The most effective, most economical, and least hazardous control is poison baits. Wheat coated with a solution of zinc phosphide is the most widely used bait in Oregon. A new bait, Ramik Brown, has been used to a limited extent in the Northwest.

Bait location is important. Meadow mice stay close to their established runways, so place the bait directly in the burrow entrances or the runways. You can make a false cover from box ends or tar paper rolls and place it over or in the runways. This cover provides the mouse with a protected dining area. Keep dogs and cats out of an orchard that has been baited.

Figure 13a.—How windrowing works. The sweeper first passes down one side of the tree row.

Figure 13b.—Then it passes up the other side, to complete the windrowing of nuts and leaves.

Moss and lichen

These can be a problem in some orchards, especially if you don't prune off the wood they infest. The most serious problem is limb breakage during heavy wet snows or ice storms. Sprays are effective in controlling these bark parasites.

Apply Bordeaux 12-12-100 or lime-sulfur (10 gallons to 90 gallons of water) in March after blossoming is complete, but before leafing out. Thorough saturation is necessary to kill the moss or lichens. Don't use these sprays during the pollination period from mid-December to late February.

Moss and lichens do not harm the tree except to encourage limb breakage. Good pruning programs and good growth of the trees usually eliminates moss and lichen problems.

Figure 13c.—Now the harvester straddles the windrow.

Harvesting

Most hazelnut harvesting operations involve two machines, one that sweeps the nuts into windrows and another that picks them up from the ground and separates them from leaves and sticks.

Figure 13d.—Next, the harvester picks up leaves, nuts, and all. Then it separates leaves and trash, blowing them to one side.

Figure 13e.—Finally, the harvester deposits nuts (plus some hulls that stick together) into a trailer.

Leaves and trash on the ground

The amount of leaves that fall before harvest is a major consideration in pickup operations. Leaf fall occurs earlier in potassium-deficient orchards.

A heavy application of nitrogen can induce a deficiency of K, thus increasing leaf fall. Drought, deep cultivation, or mites and aphids may also cause early leaf drop.

Ground preparation for mechanical harvesting

Under nontillage orchard management, little or no extra work is required to prepare the soil surface for harvest. Blank nuts fall before good nuts. A final flailing and floating to fill small depressions may be desirable after blanks have fallen and just before good nuts begin to drop.

Under cultivation, much more work is needed to prepare the soil surface for harvest. The usual procedure for ground preparation in a cultivated orchard is as follows:

1. Disk under the cover crop (or winter weed growth) with a cover crop disk, field disk, or Rototiller.
2. Use a spring-tooth harrow or peg harrow for summer weed control, often with a roller for breaking clods and a float or drag behind. Some growers use a rod weeder, Gent weeder, or Kimble.
3. Level the orchard floor, float it, and roll it in two directions to prepare for harvest. Use sprocket rollers for clod mashing and smooth rollers for firming the soil for pickup operations.

Grass and chickweed often grow after the orchard has been rolled and leveled and some nuts have fallen. Don't use herbicides at this time—they would contaminate the nuts.

Time of harvest

Rains and windy weather will bring the last hazelnuts down, but they will also create muddy conditions for the pickup operation. The downdraft from a helicopter will help remove the last portion of the crop when 90 to 95% of the crop is down, so that harvest can begin before the fall rains create difficult conditions.

A little rain before harvest helps to reduce the dust and firm up the picking surface. A once-over mechanical harvest is not possible before October in most years. Frost usually hastens nut drop.

Ethephon to loosen nuts

The hazelnut nut is mature when you can turn it in the husk by hand. This occurs several weeks before the husk spreads open and releases the nut. You can speed up husk aging and opening by applying ethephon.

The nuts are usually mature enough to be sprayed with ethephon during the last week of August or the first week in September. Thorough spray coverage of the tree is essential.

Response to ethephon is greater if high temperatures follow spraying. Nut fall from ethephon-treated trees may be nearly complete by the end of September. Be sure to follow label instructions.

Windrowing

Before the pickup operation, nuts are windrowed between tree rows into one or two rows, 2 to 4 feet wide (figures 13a to 13e). Sweepers for nuts vary in size and cost. Most growers have a leaf blower attached to their

sweepers to move the nuts away from the trees.

Most mechanical sweepers will clean the nuts from the tree row without additional hand work. Sometimes sweepers are mounted on the front end of a regular farm tractor.

Cleaning equipment on harvesters

Perhaps the greatest problem in mechanical harvesting is getting a clean product. Processors and buyers complain about "clean away" or "wash away" and usually charge the grower for additional cleaning done at the packing plant. Probably one of the cheapest places to clean the produce is in the field.

Hazelnuts present some difficult cleaning problems. Nuts must be separated from clods, hulls, blank nuts, leaves, rocks, and twigs. Cleaning methods include blowing or sucking, revolving rollers, revolving drum or "squirrel cage," and revolving tines or brushes.

One of the best places to separate leaves and nuts by blowing is as they fall from the end of a conveyor into a bin or other cleaning device. Hulling cylinders have been developed for removing husks.

The squirrel cage helps to remove leaves, clods, and small sticks, but it is too slow for most operations. The rollers pull leaves and twigs down between them and send the nuts to the rear. They work better when either completely dry or kept moist by applying water.

All of this cleaning equipment must operate rapidly enough to keep ahead of the pickup section, or the whole operation is slowed down and the nuts are not thoroughly cleaned.

Problems encountered in the cleaning process include:

1. hard clods or stones the same size as the nuts,
2. mud-clogged conveyors,
3. wet leaves that will not blow,
4. sticks and trash that jam equipment, and
5. an overall process that is too slow.

If harvest conditions are too difficult, clean the nuts partially in the field and clean them more thoroughly later in a stationary cleaner outside the orchard.

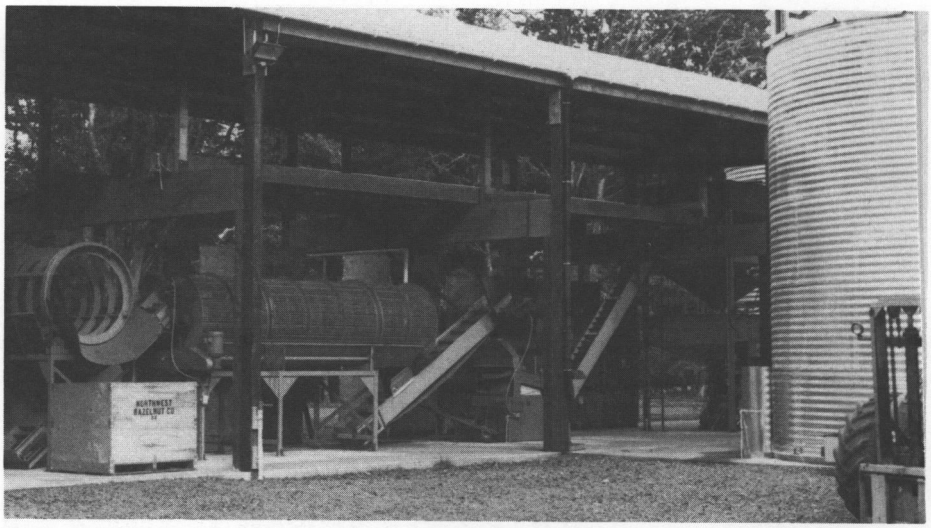

Figure 14.—Wet nuts are promptly hulled (if required) and cleaned in equipment like this.

Washing, drying, and storage

Washing

Hazelnuts that come directly from the orchard will be either dusty or muddy and may be mixed with a considerable amount of clods, sticks, leaves, and rocks (figure 14). Hazelnuts must be cleaned before buyers will accept them, and cleaning is most easily done before drying the nuts.

Most driers are equipped with a processing line that includes a derocker to remove rocks and dirt clods; a squirrel cage washer to remove mud, sticks, and leaves; and a fresh water rinse to finish the washing operation.

Sanitizing equipment, using chlorine to kill harmful bacteria, is the latest addition to the washing line. This treatment is necessary because there is not enough heat in the drying process to sterilize the nuts to the recommended standard.

Drying

Do not store damp or undried hazelnuts (and this condition is not always evident from the appearance of the shells) for any length of time because kernels may become moldy or off-flavored.

To avoid loss of weight and spoilage, dry your hazelnuts to a moisture content of 8 to 10%. Since nuts are bought and sold on a dry-weight basis, one of the most important factors affecting the price you as producer will receive is the amount of moisture in the crop you deliver. The best drying temperatures are 90 to 100°F. Forced air circulation is as important as temperature in proper drying.

Many inexpensive, fairly efficient dryers have been made by remodeling old buildings on the farm. Place the heating unit so that it will provide an equalizing chamber under the drying bins and thus ensure even amounts of warmed air passing up through all parts of the nut-drying area.

The drying floor can be made of wire cloth or expanded metal laid on strips 1 × 2 inches or 2 × 3 inches. At least 80% of the floor space should be open, allowing air to pass upward. Provide outlets in the roof of sufficient size to allow free upward movement of moisture-ladened air. Ducting to allow recirculation of the air through the

dryer can reduce fuel requirements. Few growers maintain drying temperatures continuously for 24 hours a day.

There has been a recent trend toward onfarm dryers using grain-drying structures (figure 15). Although they may be more costly to purchase than modified buildings, their greater capacity may make their use economically justifiable.

You can dry small lots of hazelnuts by spreading them out a few layers deep on the floor in a dry room. Stir the nuts frequently.

With hazelnuts, the kernel is firm at the start and becomes spongy during the drying process; as it approaches dryness, it becomes firm again. Starting at the outside of the kernel, the color gradually changes from white to a creamy color. When the color change reaches the center of the kernel, the nut is dry.

Careful checking of both firmness and color will help determine when the nuts have dried enough.

Sulfur vapor is often used to sanitize inshell nuts.

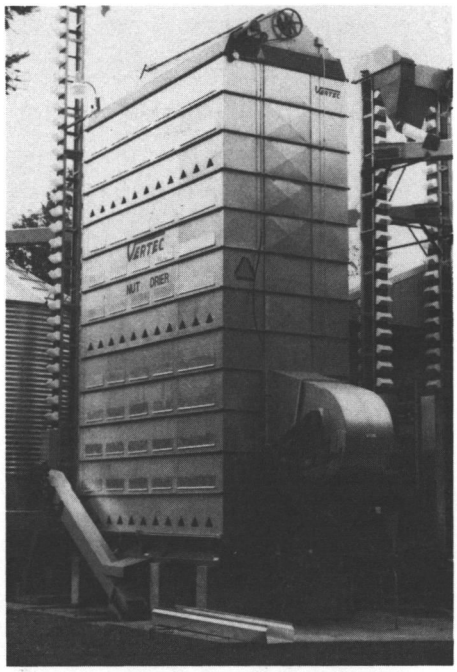

Figure 15.—After cleaning, the nuts are dried. This is one of the new types of onfarm driers that have recently come into use.

Storage

Storage is usually not the producer's concern, since you normally sell the hazelnuts undried as you harvest them from the orchard or immediately after drying.

For common storage, dry nuts at 100°F or less to a total moisture content of 7 to 8% for inshell nuts, 3½ to 4½% for shelled nuts. Use properly sealed plastic liners in boxes, bags, or bulk bins and store at 70°F or below. Nuts will keep satisfactorily for up to a full year.

For refrigerated storage, after drying, store nuts at 32-35°F for as long as 2 years if packaged in sealed plastic or burlap bags when relative humidity is maintained at 60 to 65%. Store nuts away from odor-producing substances. After storage, allow nuts to warm in unopened bags (in a well-ventilated area if you don't use plastic bags).

For freezer storage, you can store dried nuts at 27°F or lower for 2 years, with or without plastic containers. After storage, allow nuts to warm as in refrigerated storage.

The full flavor of hazelnuts is brought out only by roasting. Place the shelled kernels in an oven at 275°F for 20 to 30 minutes or until the skins crack. After cooling, the kernels should be fairly crunchy, not rubbery. Roasted hazelnuts will go rancid at room temperature very quickly, but you can hold them in a freezer for a long time.

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